EVIDENCE OF STREAM MOTION AFFORDED BY THE FAINT STARS NEAR THE ORION NEBULA

By Adriaan van Maanen

Mount Wilson Observatory, Carnegie Institution of Washington

Communicated by G. E. Hale. Read before the Academy, April 28, 1919

The increased accuracy which can be obtained in the determination of proper motions of the stars by long-focus instruments makes it necessary to take into account quantities which otherwise could be neglected. When the probable error of the motion in a coordinate becomes as small as $0\overset{''}{.}003$ or $0\overset{''}{.}004$, we may no longer neglect systematic errors of this size or larger, if they can possibly be determined.

In a discussion of the proper motions of 85 stars in the region of the Pleiades,[1] photographed with the 80-foot focus of the 60-inch Mount Wilson reflector it was found that in the reductions the quadratic terms of the coordinates could not be neglected, notwithstanding the fact that the size of the field was only 24 by 30 minutes of arc. For this and other reasons it was suspected that by neglecting such terms in a former discussion of the proper motions of 162 stars near the Orion nebula,[2] photographed with the 40-inch Yerkes refractor, we had not attained the best possible results. A new solution has therefore been made including the quadratic terms; the necessary corrections are of the same order as those for the Pleiades field and may not be neglected. The comparison reveals the relative efficiency for this kind of work of the long-focus reflector, which seems easily able to withstand a comparison with the refractor.

The fact that we are here dealing with a field in which many of the stars must belong to the nebula, especially in the center of the plates, has its disadvantages, as well as its advantages, for, the motion of the nebula being small, we cannot separate by their proper motion alone the individual stars belonging to the nebular system. This necessitates the exclusion for reference purposes of most of the central stars, whereby the weight of the reductions is considerably lessened.

On the other hand, from the abundance of stars near the Trapezium we can conclude that most of them form a part of the system of the Orion nebula. From their connection with the nebulosity other stars can also be selected as probable members of the group. Except for any internal motion, which, however, can be neglected in a first approximation, all these stars must have the same proper motion; they therefore enable us to drive any magnitude error in case such error does exist.

Another advantage of a field like that discussed here, is that, although the small field measured contains only two or three stars for which meridian observations are available, we can now use for the reduction of our relative to absolute motion all the stars in the catalogues which seem to belong to the system of the Orion nebulà. For this purpose twelve stars in Boss's *Preliminary General Catalogue* were found to be available. The motions previously derived were corrected in this way and reduced to absolute motions in Boss's system. The results for different groups of stars are as follows:

13 stars which seem to be enveloped in nebulosity have

$$\mu_\alpha = +0.''0052 \pm 0.''0020$$
$$\mu_\delta = -0.''0024 \pm 0.0024$$

32 stars near the Trapezium have

$$\mu_\alpha = +0.''0059 \pm 0.0013$$
$$\mu_\delta = -0.0021 \pm 0.0010$$

21 stars, found to be variable by different observers,

$$\mu_\alpha = +0.0046 \pm 0.''0009$$
$$\mu_\delta = +0.''0011 \pm 0.''0011$$

Excluding here three stars for which the variability is uncertain, we find

$$\mu_\alpha = +0.0049 \pm 0.''0009$$
$$\mu_\delta = -0.''0003 \pm 0.''0010$$

From this it is clear that practically all these variables must belong to the system of the Orion nebula and that their variability is therefore due to a physical connection with the nebula.

From the work of Buisson, Fabry and Bourget,[3] we know there is some evidence that the nebula rotates about an axis NW — SE, the NE portion receding, the SW approaching. As their measures are confined to the region within 2′ from the Trapezium, I have investigated whether the stars measured within the same area show the effect of such a rotation. As most of the stars seen in the densest part are likely to be on this side of the nebula, they ought to show a preponderance of motion from SW towards NE. The mean motion in this direction (27 stars) was found to be 0.''0010 ± 0.''0012, while the mean motion at right angles is 0.''0000 ± 0.''0015. This small systematic motion is well within the limits of the probable error.

For the background stars, that is, all stars not included in the other groups, the change in the mean values of μ_α and μ_δ with magnitude, and the fair agree-

ment of these values with the parallactic motion, prove that we have been successful in excluding from this group most of the stars which are connected with the nebulosity. As a further test I have constructed the diagrams in Fig. 1. The number of stars and the total motion were determined for sectors of 15°; then to smooth the curves, overlapping means for three successive sectors were formed. In order to avoid the influence of the large proper motions, stars with $\mu > 0.''050$ were excluded. The smaller diagram shows the results for the number of stars, the larger for the total motion in the different directions. If among the background stars we have included a considerable number of nebula stars, we should find a preponderance of both numbers and motion in the direction of $p = 110°$, in which the nebula is moving; the fact
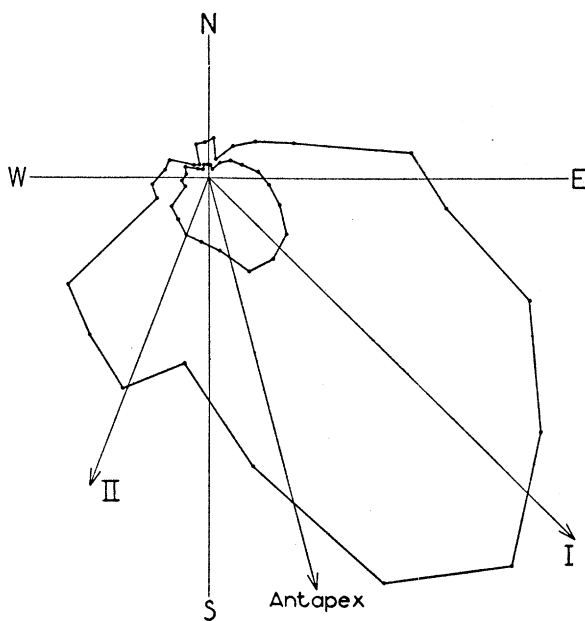

FIG. 1

that no such preponderance appears, is another proof that only a few stars of the nebula system can have been included among the background stars.

The same diagram shows that neither the maximum frequency nor the maximum motion coincides with the direction of the parallactic motion. To investigate whether this fact can be accounted for by stream-motion, I computed the direction of both streams, adopting as coördinates of the vertices:

$$\text{Stream I,} \quad \alpha = 91°, \quad \delta = -15°$$
$$\text{Stream II,} \quad \alpha = 288°, \quad \delta = -64°$$

We find for

$$\text{Stream I,} \quad p = 139°, \quad \lambda = 13°$$
$$\text{Stream II,} \quad p = 191°, \quad \lambda = 108°$$

The agreement of the maximum frequency as well as that of the maximum motion with Stream I is quite remarkable, when we take into account the small number of stars available (88), the more so as λ is only 13°; the influence of Stream II also, although not so strong, can be plainly seen.

More material for different parts of the sky will of course be necessary before we can conclude with any certainty that stars as faint as the 14th and 15th magnitudes show the stream-motion.

[1] van Maanen, Adriaan, *Mt. Wilson Contr.*, No. 167, 1919.

[2] van Maanen, Adriaan, *Astr. J., Albany, N. Y.*, **27**, 1912 (139–146).

[3] Buisson, H., Ch. Fabry, and H. Bourget, *Astrophys. J., Chicago, Ill.*, **40**, 1914 (241–258).

[4] Eddington, A. S., *Steller Movements, London*, 1914, page 100.

ON THE USE OF THE SPECTROSCOPIC METHOD FOR DETERMINING THE PARALLAXES OF THE BRIGHTER STARS

By W. S. Adams and G. Strömberg

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

Read before the Academy, April 28, 1919

When the method of deriving the luminosities and the parallaxes of stars by means of the intensities of certain lines in their spectra was developed by Adams and Kohlschütter a few years ago the applicability of the method to the stars of highest luminosity and smallest parallax was necessarily somewhat uncertain. This was due to the fact that the method depends upon the calibration of a scale of line-intensities by means of stars of known parallax and magnitude, and that at this time the observational material for stars of small parallax was necessarily scanty and subject to relatively large percentage errors. All that could be done was to select a few stars with the best parallaxes, so far as could be estimated, and base upon them a set of provisional reduction-curves for the spectroscopic determinations. As a result the values for the absolute magnitudes derived in this way while sufficiently accurate to indicate clearly that the parallaxes of certain stars were very small were not of such a quality as to show in all cases the slight differences between individual stars of small parallax.

The situation has improved greatly in recent years. On the one hand the parallaxes of a large number of stars have been measured with high accuracy by various observers with the aid of photographic methods. On the other hand the amount of spectroscopic material for the stars of various magnitudes and proper motions has accumulated to such an extent that use can be made of the extremely valuable method of determining mean parallaxes for groups of stars from the parallactic motion. Accordingly it has now become possible